RISK AVERSION AS EFFORT INCENTIVE: A CORRECTION AND *PRIMA FACIE* TEST OF THE MORAL HAZARD THEORY OF SHARE TENANCY

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Abstract

We show that Stiglitz's (1974) classic principal-agency theory of share tenancy does not imply, as alleged, that the optimal tenant share is less than one for risk-averse tenants nor that the share decreases monotonically with the tenant's inherent risk aversion. Tenants may self insure by working harder--increasingly so for higher levels of risk aversion--with the result that the more risk averse work for higher instead of lower shares. When the model is parameterized based on previous studies of Philippine agriculture, it predicts a U-shaped relationship between optimal tenant's share and inherent risk aversion. Landlords choose rent contracts for both high and low levels of risk aversion. For intermediate levels, the optimal sharing rates are 80% and above. In contrast, actual sharing rates in the study area ranged from 50-60%, with most farmers contracted on a 50:50 basis. We conclude that the risk-aversion *versus* moral hazard theory of tenure choice is incomplete. Rent contracts must have additional disadvantages and/or share tenancy additional benefits that are not accounted for in the static principal-agency theory.

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1. Risk, Incentives and Tenure Choice

One of the earliest formulations of principal-agency theory can be found in the Stiglitz (1974) model of contract choice in agriculture. In this canonical account of the hidden action problem, the output of a landlord's farm depends on both the labor-effort of his risk-averse tenant and a random state of nature. Because the effort input is unverifiable, it cannot be directly specified in the contract--which sets only a tenant's share (α) and a fixed side payment (β)--but must be induced indirectly through the incentive properties of the contract terms. This leads to a trade-off between risk-bearing and effort-shirking costs: increasing the tenant's share improves incentives but also exposes him to more risk, making it more expensive for the landlord to satisfy the participation constraint.

This model is still regarded by many economists as the most plausible explanation available for the popularity of share tenancy (*e.g.* Sappington, 1991; Hayami and Otsuka, 1993; Ray, 1998) despite conflicting empirical evidence.[3] Moreover, the theory has, of yet, not been successfully used to explain an actual sample of tenancy contracts. Indeed, for the study area covered below, it seems unlikely that the theory can make accurate predictions. In the Philippines, and elsewhere in Asia, the distribution of tenancy contracts is trimodal and 'U' shaped with 50:50 sharing being the most common contract, fixed-lease (rent) ranking second and 'lease-share' (tenant's share in the neighborhood of 2/3) third (Hayami and Otsuka, (1993)). At the same time, however, studies of the distribution of risk preferences among low-income farmers (Binswanger, 1980; Sillers, 1980; Grisley, 1980; Walker, 1980; Binswanger and Sillers, 1983) show that this is unimodal and bell-shaped. If the Stiglitz theory is correct, this would imply that contracts would have a unimodal, bell-shaped distribution as well.

Our original objective was to develop a methodology for testing the moral hazard *versus* risk-bearing theory of share tenancy. We calibrated the Stiglitz model using Philippine evidence on production and risk aversion and found that it fails to predict the popularity of 50:50 sharing (the most popular contract). In addition, the simulation showed that increasing tenant risk aversion from moderate to severe levels causes the optimal contract to switch from share tenancy to rent. Inasmuch as the latter finding is inconsistent with Stiglitz's central proposition, we re-examined his theory and found that his equations do not justify the proposition attributed to them. In Section 2 below, we show that, contrary to his assertions, Stiglitz's model does not imply that the optimal tenancy share decreases with the tenant's risk aversion nor that the optimal share for a risk-averse tenant is necessarily less than one.

Section 3 provides the simulation methodology and an illustration thereof based on secondary information about tenant farmers in Nueva Ecija, Philippines. The results show that rent may in fact be optimal for risk-averse tenants and that the optimal share is not necessarily decreasing in tenant risk aversion. The optimal share is 100% (*i.e.* rent) for risk- neutral individuals, declines to 80% for the moderately risk averse and then rises to 100% for the highly risk averse. The model predicts that all of the tenants for whom risk preferences were measured should be observed to have shares of 80% or higher with rent (100% tenant share) being

[3] Rao (1971), Reid (1973) and Allen and Lueck (1999) have found that high-risk crops are more likely to be farmed on a fixed-rent basis. This finding has been attributed to the correlation between high risk and scope for managerial discretion and to the observation that rent contracts incentivize managerial effort as well as labor effort. Similarly, Prendergast's (1999) survey found only weak support for the idea that a trade-off between risk and incentives is an important determinant of contractual arrangements between firms and their employees.

indicated for both the least and most risk-averse tenants. In contrast, 58% of farmers in the study area had shares of 1/2, 12% had shares near 2/3, and the remaining 30% rented the land on a fixed fee basis.

2. Risk Aversion and Shirking Incentives

The canonical model of the insurance/incentives trade-off in contract choice is introduced in Stiglitz (1974), Part II. Output in the absence of any crop damage is given by:

$$Q = T f(el), \tag{1}$$

where T is the total acreage owned by the landlord, e is each tenant's (unobservable) effort level and l is the number of tenants per unit of land. Tenant income (Y) and utility (U) are then given by:

$$Y = \{ \alpha f(el) / l \} g + \beta \tag{2}$$

$$U = E[U(Y)] + V(e), \tag{3}$$

letting α denote the tenant's share, β a fixed side payment, g the percentage of the harvest left undamaged (a stochastic variable), E the expectations operator and V the tenant's disutility of effort. Given α, β and l, the tenant chooses e by solving the incentive compatibility constraint:

$$E[U' \alpha f'(el)\, g] + V' = 0 \qquad \text{(incentive compatibility constraint)} \tag{4}$$

The landlord chooses the value of β required for the participation constraint to hold with equality. This is given as a function (h) of the tenant's reservation level of utility (W), α and l:

$$\beta = h(\alpha, l; W) \qquad \text{(participation constraint)} \tag{5}$$

Finally, the landlord chooses a contract that maximizes profit subject to the two constraints. That is, he chooses α and l to solve:

$$\max_{\{\alpha, l\}} (1 - \alpha) f(el) - h\, l \tag{6}$$

The first order conditions for this problem are then shown to imply the following closed-form expression for the tenant’s share:

$$\alpha^* = \gamma\varphi \;/\; (c + \varphi) \tag{7}$$

where γ is the share of labor in the absence of uncertainty, $\varphi = (\delta \ln e / \delta \ln \alpha)_W$, e is tenant effort and $c = 1 - E[U'\, g] / E[U']$. Since $E[U'\, g] / E[U']$ is decreasing in the curvature of the tenant's utility function, Stiglitz concludes in Proposition 11 that: "If workers are risk averse, then $0 < \alpha < 1$" and "α is smaller the more risk averse the individual."

These conclusions overstate the implications of (7). First, Stiglitz overlooks the possibility that maximizing landlord profit over $\alpha \in [0,1]$ might lead to the corner solution $\alpha = 1$, as would be the case if the magnitude of the incentive effects were large relative to risk-bearing costs. Since (7) is only an interior solution, it does not imply that the optimal share must be less than one.

A second problem is that, even if the maximum does occur at the interior solution, the assertion that α is smaller the more risk averse the tenant is not generally true. This is easy to see when tenant risk aversion can be summarized by a single parameter (s) (*e.g.* as in utility functions characterized by constant absolute, relative, and partial risk aversion). In that case, letting $\zeta = 1 / (c + \varphi)$ it is straightforward to show that:

$$d\alpha / ds = \gamma \zeta [(1 - \varphi \zeta) d\varphi / ds - \varphi \zeta \, dc / ds] \tag{8}$$

The total differentials of φ and c depend on both the direct effect of a change in s (holding e constant) as well as the indirect effect of a change in s *via* the change this induces in e:

$$d\varphi / ds = (\delta\varphi / \delta e)(\delta e / \delta s) + \delta\varphi / \delta s \tag{9}$$

$$dc / ds = (\delta c / \delta e)(\delta e / \delta s) + \delta c / \delta s \tag{10}$$

Finally, the direct effect of a change in s on φ is given by:

$$\delta\varphi / \delta s = (\alpha / e) \{(\delta / \delta\alpha[(\delta e / \delta s)] - (1 / e) (\delta e / \delta\alpha)(\delta e / \delta s) \} \tag{11}$$

Since Stiglitz does not consider the effect of risk aversion on effort, he is implicitly assuming that $\delta e / \delta s = 0$, in which case, $\delta\varphi / \delta s = d\varphi / ds = 0$, $dc / ds = \delta c / \delta s$ and $d\alpha / ds < 0$ as claimed. (Note that γ, ζ, φ and $\delta c / \delta s > 0$.) In general, however, the incentive compatibility constraint (4) implies that effort is a function of inherent risk aversion, *i.e.*, $e^* = e^*(s)$ and $\delta e / \delta s \neq 0$. Consider, for example, what happens if the tenant's risk premium is decreasing in expected income. In that case, an increase in s might imply a higher value for e^*, since this would partially offset the increase in risk premium associated with greater risk aversion (by raising expected income). We would then have $\delta e / \delta s > 0$--the more risk averse would work harder.

In particular, so long as e is increasing in α (so that $\varphi > 0$), $d\alpha / ds < 0$ iff:

$$d\varphi / ds < [\varphi \zeta / (1 - \varphi \zeta)] \, dc / ds \tag{12}$$

$\varphi > 0$ implies that $0 < \varphi \zeta < 1$ and $[\varphi \zeta / (1 - \varphi \zeta)] > 0$ (since risk aversion implies $c > 0$).

Thus, α will be monotonically decreasing in tenant risk aversion if and only if one of the following three mutually exclusive conditions holds[4]:

1) $d\varphi / ds$, $dc / ds > 0$ and $d\varphi / ds$ is 'small' relative to dc / ds.

2) $d\varphi / ds < 0$, $dc / ds > 0$.

3) $d\varphi / ds$, $dc / ds < 0$ and the absolute value of $d\varphi / ds$ is 'large' relative to that of dc / ds.

However, we may also have either: (1) $d\varphi / ds$ is positive and 'large' relative to dc / ds or (2) $d\varphi / ds > 0$, $dc / ds < 0$. Since Proposition 11 would not hold in either case, it follows that it is not generally true and must be rejected on logical grounds. Nor is there an apparent reason to claim that one of the required conditions for Proposition 11 is 'likely' to hold empirically. Consider again a tenant whose risk premium is decreasing in expected income. dc / ds might be 'small' or even negative because, while increasing risk aversion increases c for a given value of e, the value of e^* may be higher for more risk-averse tenants as described above. As a result, we might find that the direct effect of a higher value of s was largely (or conceivably even more than entirely) offset by the indirect effect (*via* the change in e^*).

As for $d\varphi / ds$, note first that there are two reasons to expect that e will be increasing in α. First, as noted *e.g.* by Marshall, a higher tenant's share raises the benefit of an increase in effort at the margin because the tenant receives more of the associated increase in output. Second and less commonly recognized, because a higher value of α increases the risk premium at a given effort level by increasing the variance of the tenant's income, it may result in a (partially or fully) offsetting increase in e^*. If greater risk aversion implies that a greater increase in e^* results from the same incremental increase in α, we will have $d\varphi / ds > 0$ and there is no reason to suppose that the magnitude of this effect will be small.

The trade-off between insurance and incentives is thus not as straightforward as is generally believed. On the one hand, insurance considerations suggest that increasing the tenant's share beyond some point will increase the risk premium more than the incentive benefits. At the same time, however, if the incentive effect associated with the increased share is greater the more risk averse the tenant, the net effect on the sum of risk-bearing and labor-shirking costs will be ambiguous.

Stiglitz's proof that (1) $\alpha < 1$ for risk-averse tenants and (2) α is monotonically decreasing in risk aversion is clearly insufficient. In subsequent sections we provide a numerical example in which: (1) rent is the optimal contract for both risk-neutral and substantially risk-averse tenants and (2) increasing risk aversion leads first to a decline in α as expected but then to an increase. In the case we consider, it is only for moderately risk-averse tenants that share tenancy is optimal, and, even then, the tenant's optimal share is so high that the contract closely resembles a fixed lease.

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[4] Any one of the three conditions is sufficient for the modified proposition to hold and one of the conditions must hold in order for the proposition to be true.

3. Simulating the Optimal Tenant Share

In this section we explore the extent to which the risk-bearing-*versus*-moral-hazard theory, appropriately modified, can explain the distribution of tenancy contracts in a typical rice growing area in the Philippines. The previous section established that Stiglitz's proof of his Proposition 11 is invalid. But while there is no reason to assume that his result must hold in general, it is still possible that the monotonically negative relationship between optimal tenant share and risk aversion holds. Lacking direct evidence on these assumptions, one can simulate the implied relationship between risk aversion and the size of the tenant share for a sample of tenants to see to what extent the monotonicity hypothesis can be verified. Even if the monotonicity restriction is rejected, there is still the question of whether the unrestricted theory can successfully explain an empirical distribution of tenant shares. Both questions are the object of the following.

As is now common in the 'development microeconomics' literature, we assume that effort shirking takes the form of stinting hours (see *e.g.* Ray, 1998). While hired labor works at specific times and is typically supervised, thus rendering the stinting of hours in the field an infeasible strategy, share tenants are not supervised and work at their own discretion. Working at suboptimal effort levels is a dominated strategy since tenants are free to choose the number of hours that they spend in the field.[5]

We abstract from the problem of the landlord's choice of l and assume Cobb-Douglas production with constant returns to scale and labor and land as the only inputs:

$$q = g\, C\, \lambda^{a} \tag{13}$$

where q is output per hectare, g is the stochastic damage variable, C is a constant, λ is labor per hectare, and a is the output elasticity of labor.

A tenant's total income, net of the opportunity cost of his labor input (w), is given by:

$$\pi = D\,(\alpha\, q + \beta - w\lambda) \tag{14}$$

where D is the total number of hectares farmed. We follow the empirical literature on farmer risk preferences and assume that the tenant has the constant partial risk aversion utility function (CPRA) described in Binswanger (1980, 1981) and Sillers (1980):

$$U(\pi) = (1\text{-}s)\,\pi^{(1\text{-}s)} \tag{15}$$

Following Antle and Goodger (1984), we may express expected utility as a function of the first three moments of the probability distribution for the random variable (g) by expanding the utility function about the expected value of the tenant's income ($\bar{p}$), taking expectations and ignoring higher order terms:

[5] For further details on the nature of shirking under different contractual arrangements and the distinction between hired labor and tenancy, see Roumasset and Uy (1980) and Roumasset (1995).

$$E\,[U(\pi)] \cong (1\text{-}s)\ \bar{p}^{\ (1\text{-}s)} - s\,(1\text{-}s)^{2}\ \bar{p}^{\ -(s+1)}\ \mu_{2}/2 + s\,(s+1)(1\text{-}s)^{2}\ \bar{p}^{\ -(s+2)}\ \mu_{3}/6 \qquad (16)$$

where μ_i denotes the $i^{\underline{th}}$ moment of the probability distribution for the tenant's income. The tenant's incentive compatibility constraint is given by:

$$[\bar{p}^{\ -s} + s(s+1)\,\bar{p}^{\ -(s+2)}\ \mu_{2}/2 - s(s+1)(s+2)\,\bar{p}^{\ -(s+3)}\ \mu_{3}/6]\ \delta\bar{p}/\delta \boldsymbol{l} = (s/2)\ \bar{p}^{\ -(s+1)}\ \delta\mu_{2}/\delta \boldsymbol{l} - (s/6)(s+1)\,\bar{p}^{\ -(s+2)}\ \delta\mu_{3}/\delta \boldsymbol{l} \qquad (17)$$

The goal of the simulation is to calculate the optimal tenant share over a domain of risk aversion. This in turn facilitates a comparison of shares predicted by the moral hazard model and the distribution of actual shares in the study area. Specifically, we want to establish how often the model predicts that the most popular contracts (1/2 and 2/3 shares and rent) would be chosen under realistic levels of output variance and skewness, assuming tenants drawn from a pool of farmers with identical risk preferences to the participants in the Sillers (1980) study. This information may then be compared with empirical evidence on the prevalence of these contracts to determine whether or not the simulation results are consistent with what is observed.

The first step is to solve for the opportunity cost (w) of tenant labor. Then, assuming that the share has already been chosen, we may solve the participation and incentive compatibility constraints simultaneously for $\boldsymbol{l}^*$ and β. As this cannot be done analytically, the software package *Mathematica* (Version 3.0) is used to find solutions numerically for given values of risk aversion (s), variance(σ^2), skewness (K), tenant's share (α) and elasticity of effective labor (a). (See Appendix 1 for the commands used.)

Having determined $\boldsymbol{l}^*$ and β, it is straightforward to find the corresponding landlord profit. Finally, this procedure is repeated for other share values, the resulting profits are compared and the landlord's profit- maximizing share is chosen.

Before presenting the results, it is necessary to describe the sources for the parameter values used. Values for the coefficients of partial risk aversion came from Sillers (1980). We also used statistics on rice production from Laguna Province, Philippines. In that area, prior to the land reforms of the mid-70's, share tenancy was one of the most common agricultural contracts --about 70% of the farms in the two villages studied by Hayami and Kikuchi (1981) were under share tenancy contracts prior to 1976. Hayami and Kikuchi (1981, Chapter 6) found an output elasticity of labor of .27 for small farms under rental contracts. If we imagine all other factors being held constant at their average values, this would imply the Cobb-Douglas production function:

$$\ln q = 0.27\ \ln\ \boldsymbol{l} + \ln C \qquad (18)$$

Output per hectare for these farms was about four tons per season, while the labor input was 105 man-days per hectare. Using this data, we find that C= 1.14, implying:

$$q = 1.14\ \boldsymbol{l}^{\ 0.27} \qquad (19)$$

If 36% of the crop was lost to pests, typhoons and other natural causes, as was typical for the Laguna farms surveyed in Roumasset (1976, Chapter 5), in the absence of such crop damage (*i.e.*, g =1), output would have been 6.3 tons. Assuming the same factor shares under these ideal conditions, we would have found C = 1.78 implying:

$$y = 1.78\, g\ \boldsymbol{l}^{\,0.27}. \tag{20}$$

Next, we need to solve for w. Since (20) was derived from data on farms under rent contracts, it seems reasonable to use a value for which the model's prediction is consistent with Hayami and Kikuchi's observations. We should find both that rent would be optimal and that the tenant chooses $\boldsymbol{l}^*$ = 105. To do this calculation, we need two additional pieces of information--the first three moments of the g distribution and a risk- aversion level for the typical renter. We derive the moments of the g distribution from data on crop damage for the municipality of Binan (Laguna, Philippines) presented in Roumasset (1976, Table 5.5). This was obtained from interviews with a group of thirty-three farmers on crop damage for the years 1969, 1970 and 1971. Their reports on percentage losses relative to the undamaged maximum have a sample mean of 0.64, variance of .08 and skewness of -.014. (Roumasset (1976) also reports that farm sizes (D) of 2 hectares are typical for this area. This is used in (14) to calculate tenant income.)

We used a trial and error method to find a value of w consistent with the following three points: (1) the tenant optimally chooses λ = 105, (2) the landlord optimally chooses a rent contract and (3) the moments of the g distribution are those given above. The result was w = .011. (See Appendix 2 for details.)

We generated results for values of s from 0 to 7.5 in increments of .05.[6] For each value of s, we computed landlord profit for eleven contracts: α = 50%, 55%, …, 100%. Figure 1 plots the profit-maximizing share (α^*) as a function of s. We find that α^* is only decreasing in s for values from s = 0 to approximately 0.65. For higher levels of risk aversion, α is increasing in s and rent is optimal for all s > 1.

To understand how a higher degree of risk aversion may result in a higher optimal share, consider the Taylor series expansion,

$$E\,[U(\pi)] \cong (1\text{-}s)\ \bar{p}^{\,(1\text{-}s)} - s\,(1\text{-}s)^{2}\ \bar{p}^{\,-(s+1)}\,\mu_2 / 2 \\ + s\,(s{+}1)(1\text{-}s)^{2}\ \bar{p}^{\,-(s+2)}\,\mu_3 / 6 \tag{16'}$$

A higher value of e increases $\bar{p}$, which lowers the disutility associated with μ_2 and μ_3 because they are weighted by factors of $(1 / \bar{p}^{(s+1)})$ and $(1 / \bar{p}^{(s+2)})$ respectively. And higher values of s increase the extent to which increased effort reduces these weights. In other words, insurance effects are not necessarily more important for more risk-averse agents. When s is low, this is the case because the effect of an increase in $\bar{p}$ on the second and third terms in (16') is relatively small. But with higher values of s, the tenant can mitigate the poor insurance properties of higher shares through a $\bar{p}$- increasing choice of e. In this case, insurance is relatively unimportant and higher shares are preferred for their positive incentive effects. In terms of our

[6] Note that reservation utility changes from individual to individual (as we change s) while w is held constant (at w =.011).

earlier discussion, when s is low, $d\varphi / ds$ is 'small' relative to dc / ds and Stiglitz' Proposition 11 holds; while when s is high, the reverse is true.

Sillers found that 43% of his survey participants fell in the 'intermediate' risk-aversion category, with $0.812 < s < 1.74$. Assuming that individuals were distributed uniformly throughout this range, we would have $1 < s < 1.74$ for about 80% of this group -- *i.e.* for about 34% of all participants; $0.812 < s < 1$ for about 20% of this group, or 9% of participants. For 49% of participants, $0 < s < 0.812$, while for 8%, $s > 1.74$. Thus, Figure 1 suggests that shares between 80% and 100% should be the most commonly observed contracts, as we have $0 < s < 1$ for about 58% of participants. Similarly, we should find that rent contracts account for the remaining 42%.

Figure 2 compares these results with the findings of two empirical studies of tenure arrangements in southeast Luzon. Previous studies have found that the distribution of tenure choice in the study area is 58%, 1/2 shares, 30%, fixed lease (rent) and 12%, shares in the neighborhood of 2/3. (Mangahas *et al*, 1976; Hayami and Kikuchi,1981) Evidently the model does a poor job of replicating the observed contract distribution. It fails to predict that share tenancy as it exists in the Philippines ($\alpha = 1/2, 2/3$) would be observed at all and predicts instead that shares between 80% and 100% would be the most common, although these are never observed. The model's prediction that 42% of tenants would rent is also considerably higher than the 30% reported by Hayami and Kikuchi.

Note that these differences between predicted and observed contract distributions cannot be attributed to sampling error. No matter how risk preferences are distributed among low-income farmers, we would always find that zero percent of the contracts would be predicted to specify 1/2 and 2/3 shares because these are not found to be optimal for *any* value of s. We can thus categorically rule out the possibility that the observed distribution was generated in accordance with the model in question. In short, the canonical theory is rejected at the 0% significance level.

4. Conclusion

Stiglitz's theory of share tenancy serves as an important prototype for principal-agency theory and demonstrates the possibility that share contracts can emerge as the pairwise-efficient result of rational choice. But a theory of share tenancy must do more than demonstrate the possibility of existence. It should be capable of explaining the pervasive stylized facts of tenure choice. The proposition that the optimal tenant share declines with risk aversion, combined with the frequently-observed unimodal distribution of farmer risk preferences, implies a unimodal distribution of tenancy shares. But the actual distribution of shares is U-shaped and trimodal, with 50% being both the most frequent and lowest share reported and 100% being the second most common share.

The inconsistency between apparent theory and evidence is partly due to a failure to articulate the labor-shirking-*versus*-risk-bearing theory correctly. The theory does not establish, as Stiglitz continues to claim,[7] that the optimal tenancy share decreases with the tenant's risk aversion, nor that the optimal share for a risk-averse tenant must be less than one. In particular, the optimal share is not necessarily decreasing in risk aversion. On the one hand (as the

[7] See, *e.g*. Stiglitz (1993).

conventional theory argues) the more risk averse the tenant the greater the benefit from the 'insurance' implicit in a lower share. At the same time, however, lower shares also imply lower expected income (because effort is lower), which may in turn imply an increase in the risk premium. If this risk-premium increase is greater the more risk averse the tenant, this effect will imply that the optimal share may be increasing in tenant risk aversion.[8]

We find that the monotonicity theorem is not generally valid--one of three mutually exclusive conditions must be true for the optimal tenant share to be declining in risk aversion. Rejecting this categorical theory leads to two empirical questions about the non-categorical (unrestricted) theory that remains. First, when the theory is parameterized to fit a particular study area, does it predict that tenant shares are monotonically declining in risk aversion? Second, even if the answer to the first question is no, can the non-categorical version of the theory explain the actual pattern of tenancy choice in the study area?

A simulation of the principal-agency model based on Philippine evidence reveals that the answer to both questions is 'no'. The model actually predicts a U-shaped relationship between α and *s*, with the tenant's optimal share decreasing from 100% to 80% and then increasing back to 100% with increases in the tenant's degree of risk aversion. Furthermore, for the sample of tenants for whom risk aversion was measured, the predicted contract distribution has the 42% of the sample with the lowest and highest degrees of risk aversion becoming fixed lessees and the remaining 58% of tenants getting shares from 80-100%. That is, in contrast to the standard labor-shirking-*vs.*-risk-aversion story, it is only for moderately risk-averse tenants that share tenancy is optimal. Even then, the optimal share is so high that the contract closely resembles a fixed lease. The predicted distribution contrasts starkly with the actual distribution wherein 58% of tenants receive 50% of the harvest, 12% receive approximately 2/3, and 30% rent on a fixed-lease basis.

In summary, risk aversion appears to be insufficient to explain 50:50 sharing or even its less popular 2/3:1/3 cousin. There must be some additional disadvantage of fixed lease contracting or additional advantage of sharing to reconcile observation with theory. This lends some support to the partnership (*e.g.*, Reid, 1973; Murrel, 1983) and/or asset-abuse (*e.g.* Allen and Lueck, 1992) hypotheses. The former suggests that the additional advantage of sharing is that it helps to preserve the landlord-tenant relationship in extreme states of nature, thus minimizing transaction costs. Under a share contract, the tenant's payment to the landlord falls when output is low, making him less likely to quit, while the landlord's income rises when output is high, making him less likely to renege on the original agreement. The possibility that the tenant may abuse the landlord's assets (for example, by using farming techniques that raise short-term yields at the expense of soil quality) implies a second advantage of sharing: the incentive for such abuse is decreasing in the tenant's share.[9]

One cannot rule out the possibility that, in other economic environments and for other parameterizations, risk aversion and labor shirking alone may be adequate to explain a sample of tenancy contracts. Our discussion casts doubt, however, on the presumption that share tenancy is

[8] A more fundamental problem with the theory is that it assumes agents maximize expected utility--an assumption on which the experimental economics literature has cast considerable doubt (see Camerer (1995) for a summary).
[9] Goldberg (1990) suggests that, in analyzing institutional arrangements, the opportunity cost of including risk aversion may be abstracting from more fundamental causes (such as what we now call two-sided and double moral hazard). The modeler may thus be better off focusing solely on such transaction-cost based arguments and abstracting from risk aversion entirely, even when individuals do exhibit risk-averse preferences.

primarily a reflection of risk aversion. There is no evidence to suggest that risk-bearing is as important in contract choice as incentives against shirking. Moreover, one cannot necessarily regard risk-bearing and incentives against labor-shirking as independent counterweights. Risk aversion will itself be a deterrent to labor shirking when the increase in expected income implied by higher effort leads to a reduction in the risk premium by moving the tenant to a less curved portion of his utility curve. Accordingly, one should not necessarily expect large (static) efficiency gains from land reform.[10]

Despite the fact that the canonical theory of share tenancy does not survive close analytical and empirical scrutiny, it remains a pioneering work that innovated both principal-agency theory (along with Ross, 1973) and "development microeconomics" (see e.g. Bardhan and Udry, 1999; Meier and Stiglitz, 2000). (This supports the view that economists are not, and should not be, logical positivists after all.[11]) Nor do our results suggest that principal-agency theory will not form the basis of a more empirically successful theory of share tenancy to come. We suspect, however, that such a theory will incorporate the investment disincentives that rent contracts contain.

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[10] Proponents of the risk-aversion theory often advocate redistributive land reform which converts tenants into owners. For example, Hoff and Stiglitz (2001) state that "… the distortions associated with a 50% share are similar to those associated with a 50% marginal tax rate."

[11] For a thorough development of this theme, see McCloskey (2001).

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Appendix 1: *Mathematica* commands.

The 'Profit' module shown below finds landlord profit for given values of the risk-aversion coefficient (risk), variance (var), skewness (skew), tenant's share (alp) and opportunity wage (wag). First, the FindRoot command finds values for the labor input (L) and side payment (b) that solve the participation and incentive compatibility constraints. (The numerical solution method uses 'c' and 'd' as starting values for L and b, respectively.) These values are then used to calculate landlord profit. The final Print command produces output in the form: 'risk', landlord profit, L, b.

```
Profit[risk_,var_, skew_, alp_,wag_,c_,d_]:=Module[{r,s, K, a, x, v,W,C,D},
r=risk; s=var; K=skew; a=alp;W = wag;C=c;D=d;
L=x/.FindRoot[

(* incentive compatibility constraint *)
{         ( 1 + (.5r(1+r)(2(1.1392a(x^.27)-v-W*x))^(-2))12.6736(a^2)s(x^.54)
                  - .1667r(1+r)(2+r)(2(1.1392a(x^.27)-v-W*x)^(-3))45.1180(a^3)(x^.81)K
                                                  )2(.3076a(x^-.73)-W)
          ==.5r(2(1.1392a(x^.27)-v-W*x)^(-1))6.8437s(a^2)(x^-.46)
          -.1667r(1+r)(2(1.1392a(x^.27)-v-W*x)^(-2)) 36.5456K(a^3)(x^-.19),
```

```
(* participation constraint *)
          2(1.1392a(x^.27)-v-W*x)- .5r(1-r)(2(1.1392a(x^.27)-v-W*x)^
          (-1))12.6736(a^2)s(x^.54)
          + .1667r(1-r)(1+r)(2(1.1392a(x^.27)-v-W*x)^(-2))45.1180(a^3)(x^.81)K
          == 0},{x,C},{v,D}][[1]]   ;

(* To find b we solve the same two equations but this time take the second element of the
solution vector ([[2]]) *)

b=v/.FindRoot[
{  (  1 +(.5r(1+r)(2(1.1392a(x^.27)-v-W*x))^(-2))12.6736(a^2)s(x^.54)
-.1667r(1+r)(2+r)(2(1.1392a(x^.27)-v-W*x)^(-3))45.1180(a^3)(x^.81)K
                                              )2(.3076a(x^-.73)-W)
==.5r(2(1.1392a(x^.27)-v-W*x)^(-1))6.8437s(a^2)(x^-.46)
     -.1667r(1+r)(2(1.1392a(x^.27)-v-W*x)^(-2)) 36.5456K(a^3)(x^-.19),
2(1.1392a(x^.27)-v-W*x)- .5r(1-r)(2(1.1392a(x^.27)-v-W*x)^(-1))12.6736(a^2)s(x^.54)
+ .1667r(1-r)(1+r)(2(1.1392a(x^.27)-v-W*x)^(-2))45.1180(a^3)(x^.81)K
== 0},{x,C},{v,D}][[2]]   ;

Print[   r," ",(1-a)2(1.1392a(L^.27) )+ 2b," ",L,"  ",b, "  "];            ]
```

Appendix 2: Calculating *w*.

Since we don't know to which of Sillers' risk-aversion categories the farmers in Hayami and Kikuchi's survey belonged, we search for suitable values of *w* for each of them. Replacing each range of values for *s* with its midpoint, we have s = 4.625 for 'severe' risk aversion, s =1.278 for 'intermediate', s = 0.564 for 'moderate' and s = 0.158 for 'slight-to-neutral'. (None of Siller's survey participants fell in the risk-loving category at the ₽500 payoff level and it also seems reasonable to rule out the 'extreme' category as this included only 2% of participants.)

Using *Mathematica*'s 'FindRoot' command, which uses a numerical algorithm based on Newton's method, we found (through trial and error) that l^* = 105 solved the participation and incentive compatibility constraints, for the following values of *w*, with α = 1 (a rent contract) and the moments of the *g* distribution derived from Roumasset (1976):

	W
4.625	0.0113
1.278	0.0110
0.564	0.0067
0.158	0.0076

We then repeated this procedure for lower values of α. This revealed that only in the first two cases would a rent contract be optimal for the landlord. As both 0.0113 and 0.0110 are approximately equal to 0.011, we used this value for *w*.

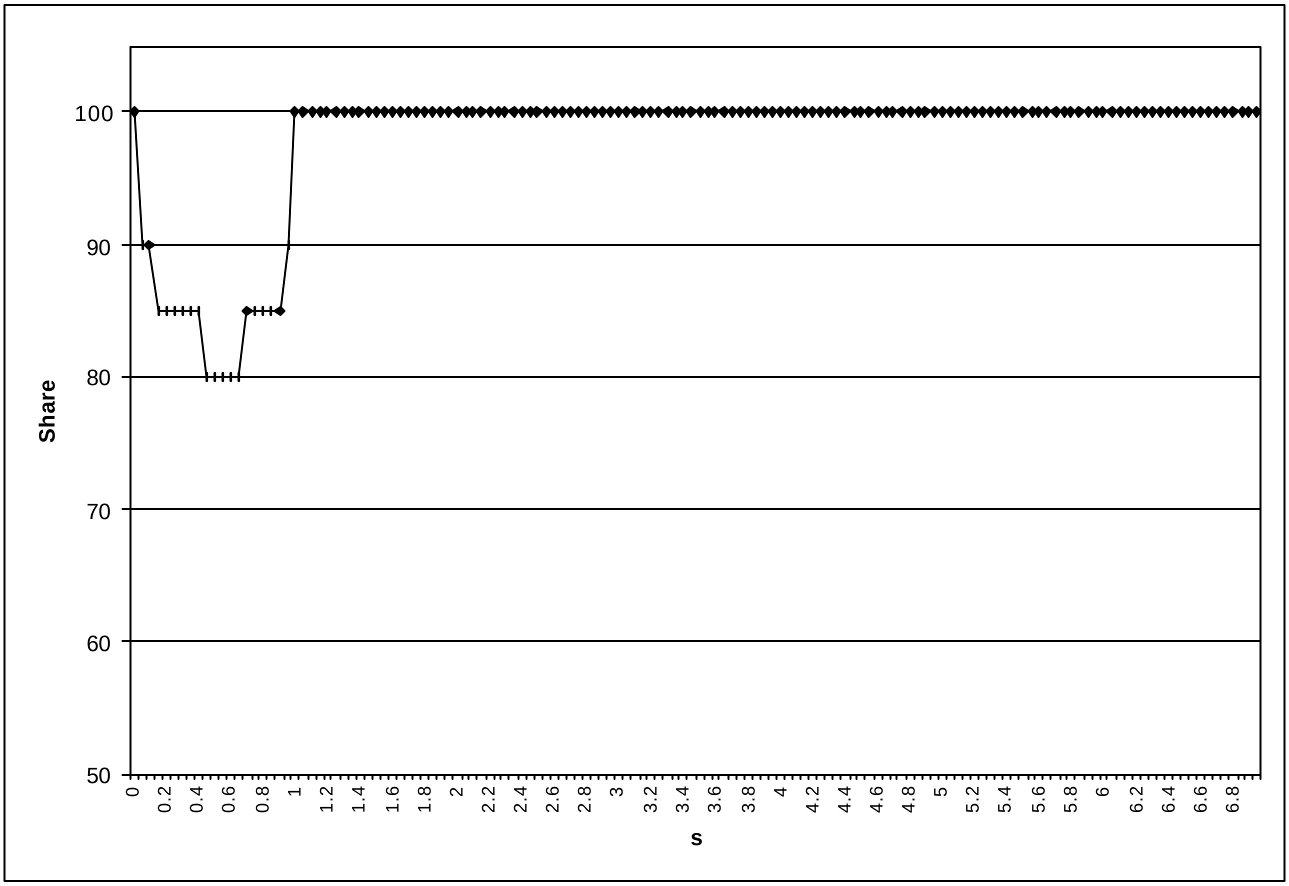

Figure 1: The optimal tenant share (α) as a function of risk aversion (s).

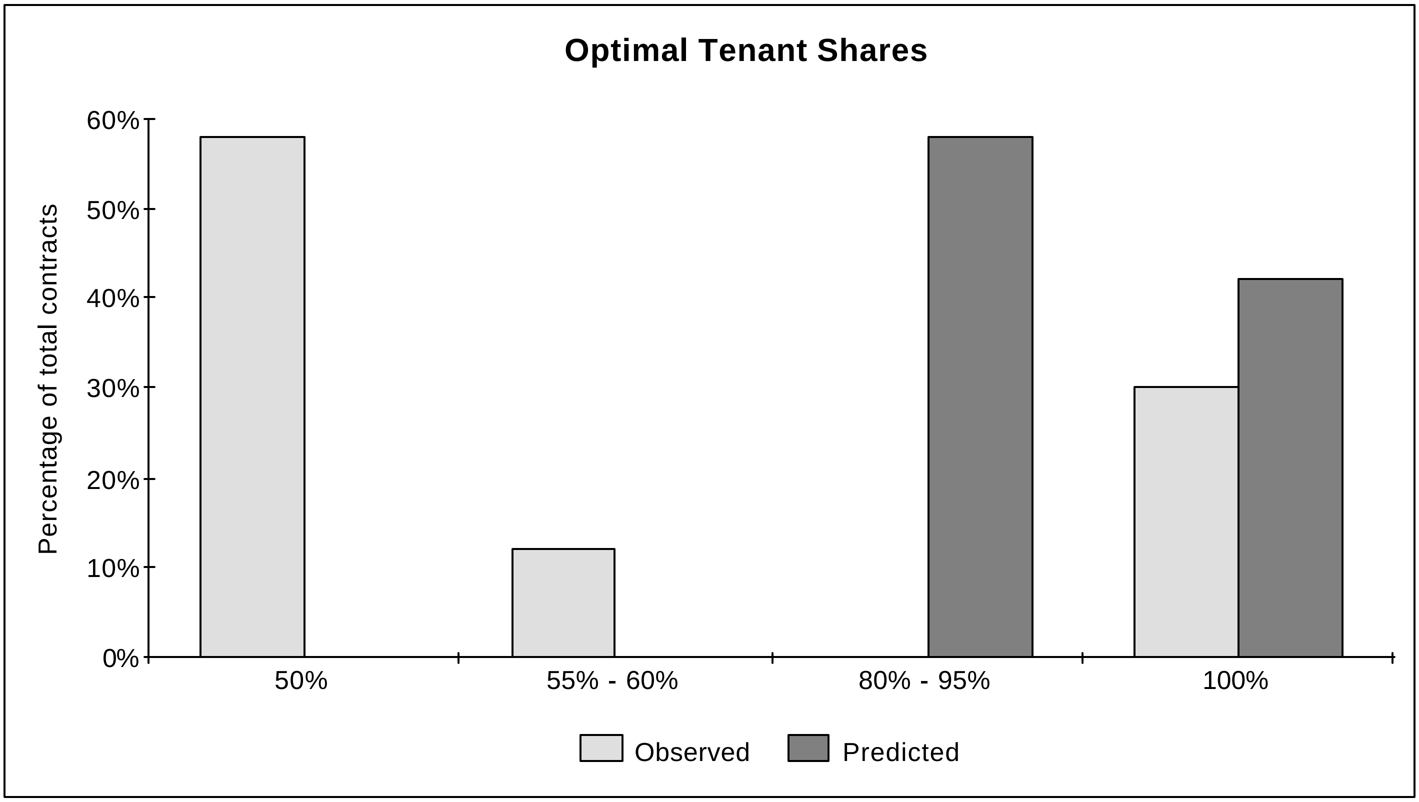

Figure 2: The model fails to predict the observed distribution of contracts.